भारतीय मानक
Indian Standard

IS 12021 : 2015

1 000 वोल्ट ए सी वोल्टता से कम के स्विचगियर और नियंत्रणगियर के नियंत्रण ट्रांसफार्मरों — विशिष्टि

(पहला पुनरीक्षण)

Control Transformers for Switchgear and Controlgear for Voltages Not Exceeding 1 000 V a.c. — Specification

(First Revision)

ICS 29.130.20; 29.180

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November 2015 **Price Group 5**

Low Voltage Switchgear and Controlgear Sectional Committee, ET 07

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by Low Voltage Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

This standard is intended to fulfill the need of a standard for control transformers for a.c. motor starter circuit feeders specifically intended to provide control supply voltage for control circuit of the starter, that is, starter coils, timers, indicating lamps, etc.

This application is distinct from other applications for transformers such as for instrumentation and protection.

The general requirements for switchgear and controlgear are covered under IS/IEC 60947 (Part 1) : 2004 'Low voltage switchgear and controlgear: Part 1 General rules'. This standard, for the purpose of clarity shall be read in conjunction with the same.

This revision has been undertaken to update it in line with IS/IEC 60947 (Part 1) : 2004. The major differences from previous edition are as follows:

a) Few terminologies added.
b) Use to term 'input' in place to 'primary' and 'output' in place of 'secondary', whenever referring to transformer parameters.
c) Preferred output voltage of 240/415V changed to 230/400V.
d) Micro environment to be considered as pollution degree 3, unless otherwise stated.
e) Use of insulating materials of Material Group III b is not recommended.

Guidelines for calculating the VA burden of control-circuits in switchgear and controlgear applications are given at Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CONTROL TRANSFORMERS FOR SWITCHGEAR AND CONTROLGEAR FOR VOLTAGES NOT EXCEEDING 1 000 V a.c. — SPECIFICATION

(First Revision)

1 SCOPE

This standard covers the requirements of dry type transformers used in switchgear and controlgear assemblies to supply power to control and/or auxiliary equipment not intended for direct connection to the main circuit. The windings of these transformers may be encapsulated or non-encapsulated.

This standard does not cover transformers such as,

a) power transformers;
b) distribution transformers;
c) instrument transformers;
d) welding transformers;
e) mining transformers;
f) earthing transformers;
g) reactors;
h) starting transformers;
j) testing transformers;
k) lighting transformers;
m) furnace transformers;
n) traction transformers for use on rolling stock;
p) transformers for use electronic equipment;
q) transformers for use with medical equipment; and
r) transformers for space heating and winding heating.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards:

IS No./ International Standard	*Title*
1076 (Part 1) : 1985	Preferred numbers: Part 1 Series of preferred numbers
1885 (Part 38) : 1993	Electro-technical vocabulary: Part 38 Transformers
3156 (Part 1) : 1992	Voltage transformer: Part 1 General requirement
9678 : 1980	Methods of measuring temperature-rise of electrical equipment
10580 : 1983	Service conditions for electrical equipment
IEC 60947 (Part 1) : 2007	Low voltage switchgear and controlgear: Part 1 General rules

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 1885 (Part 38) and the following shall apply.

3.1 Control Transformer — A transformer which supplies power control and/or auxiliary equipment not intended for direct connection to the main circuit.

3.2 Control/Auxiliary Circuit — The external circuit connected to the output terminals of the control transformer.

3.3 Rated Burden — The maximum sustained burden including the lead burden on which the performance of the control transformer is based.

3.4 Rated Short Time Burden — The value of the control circuit burden including the lead burden which occurs for specified time on which the performance of the control transformer is also based. Unless specified otherwise, this burden shall be 8 times the rated burden.

3.5 Rated Output Voltage — The voltage appearing across the output windings of the transformer when the rated input voltage is applied across the input windings with the rated burden connected across the terminals of the output windings.

3.6 Rated VA Output — The output in VA which the transformer is capable of delivering continuously when the rated input voltage is applied across the terminals of the input winding with the rated burden connected across the terminals of the output winding.

3.7 Dry-type Transformer — A transformer incorporating non-liquid di-electric media and the windings may be impregnated or encapsulated.

3.8 Fail-safe Control Transformer — A transformer equipped with a protective device or with an intentional weak part which permanently fails to function by the interruption of the input circuit when the transformer is overloaded or short-circuited, but presents no danger to the user or surroundings. It continues to meet all the requirements of this standard after removal of the overload or short-circuit.

3.9 Non-short-circuit Proof Control Transformer — A transformer intended to be protected against excessive temperature by means of a protective device, not provided, but stated on the transformer and which continues to meet all the requirements of this standard after the removal of the overload or short-circuit and if applicable, after resetting or replacing the protective device.

3.10 Short-circuit Proof Control Transformer — A transformer which shall not exceed the specified temperature rise limits when overloaded or short-circuited, and which continues to meet all the requirements of this standard after removal of the overload or short-circuit and is not required to operate continuously under overload or short-circuit condition.

3.11 Clearance — It is the shortest distance in air between two conductive parts.

3.12 Creepage Distance — A shortest distance through air along the surface of an insulating material between two conductive parts.

3.13 Pollution — Any condition of foreign matter, solid, liquid or gaseous (ionized gases), that may affect dielectric strength or surface resistivity.

3.14 Micro-environment — Immediate environment of the insulation which particularly influences the dimensioning of the creepage distances or clearances.

3.15 Degrees of Pollution — Degrees of pollution in the micro-environment established for the purpose of evaluating the clearances and creepage distances.

3.15.1 *Pollution Degree 1* — Pollution degree in which no pollution or only dry, non-conductive pollution occurs.

3.15.2 *Pollution Degree 2* — Pollution degree in which normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation may be expected.

3.15.3 *Pollution Degree 3* — Pollution degree in which conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation.

4 CLASSIFICATION

Control transformers may be classified based in the application as follows:

a) Feeder control transformer (for individual functional unit), and
b) Group control transformer (for more than one functional unit).

5 CHARCTERISTICS

5.1 Rated Voltages

5.1.1 *Preferred Rated Input Voltage*

The preferred rated input voltages shall be 230 V and 400 V.

5.1.2 *Preferred Rated Output Voltage*

The preferred rated output voltages shall be 24, 48, 110 and 230 V.

5.1.3 *Output Terminal Voltage at Rated Short Time Burden*

The voltage across the output terminals when the rated input voltage is applied across the input terminals and the output terminals connected to the rated short-time burden shall not be less than 95 percent of the rated output voltage.

5.1.4 *Output Terminal Voltage at Open Circuit*

The output voltage at open circuit shall not exceed 105 percent of the rated output voltage when the rated input voltage is applied across the input terminals.

5.1.4.1 *Rated insulation voltage*

Rated insulation voltage is the value of the voltage to which the di-electric tests, clearances and creepage distances are referred.

The maximum rated input voltage shall not exceed the rated insulation voltage.

5.1.5 *Voltage Tappings*

Unless specifically required, tappings shall not be provided. Tapping of ± 5 percent may however be provided on the input winding if required. Requirement of taps on output winding are not covered in this standard.

NOTES — Before deciding on requirements of taps, following aspects need consideration:

a) Practicality of changing taps of transformer at the same time depending on system voltage variations.
b) Necessity and feasibility of plant shut down to carry out tap changing.
c) If wrong taps are retained, problems for higher magnetising current. It is to be noted that the magnetising currents may reach as high as full load current on control transformers especially on lower ratings for switchgear and controlgear.

d) Burnout of coils, failure of indicating lamp, etc, due to over voltage and chattering and burnout of contactor coils due to lower voltages.

5.2 Frequency

5.2.1 *Rated Frequency*

Unless otherwise specified, the rated frequency shall be 50Hz.

5.3 VA Output

5.3.1 *Preferred Values*

Preferred value of VA output shall be chosen from R 10 series such as 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500 [*see* IS 1076 (Part 1)].

5.3.2 *Rated Short Time VA Output*

The control transformer shall be capable of delivering power to the rated short time burden at 95 percent of the rated output voltage. The burden is imposed at the rate of 30 times/h with equally spaced intervals the duration of each occurrence being not more than 50 ms (typically equivalent of contactor pick up time).

6 MARKING

6.1 Control transformer shall be marked indelibly with the following data. The marking shall be on the transformer name-plate permanently attached to the equipment and shall be located in a place, where it is visible and legible after the transformer is installed.

a) Manufacturer's name or trade-mark;
b) Type designation or serial number;
c) Year of manufacture;
d) Country of origin;
e) Rated input and output voltages;
f) Rated output and rated short time output, in VA;
g) Rated frequency; and
h) Class of insulation.

See Annex B for typical name plate.

6.1.1 If the available space is insufficient to carry all the above data, the equipment shall carry at least the information at **6.1** (a) and **6.1** (b) permitting the complete data to be obtained from the manufacturer.

6.2 Terminal Markings

Typical terminal marking are shown at Fig. 1. Terminal marking tapping and connection shall be in accordance with Fig. 2 [*see* IS 3156 (Part 1)].

6.3 BIS Certification Marking

The control transformer may also be marked with the Standard Mark.

6.3.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the rules and regulations made thereunder. The details of conditions under which the licence for use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

7 STANDARD SERVICE CONDITIONS

7.1 Standard service conditions shall be as per IS 10580 except that the reference ambient temperature shall be 50°C.

NOTE — A higher reference ambient temperature is recommended for design purpose on account of the fact that control transformer are mounted in enclosures with switchgear and controlrear assemblies.

7.2 Unless otherwise stated, the micro-environment is to be considered as Pollution Degree 3.

8 STANDARD CONDITIONS FOR CONSTRUCTION [*see also* IS/IEC 60947 (PART 1)]

8.1 General

The transformer shall be single phase, two winding, natural air cooled and suitable for mounting within enclosure with switchgear and controlgear assemblies.

The winding shall be of copper. Insulating materials used shall be class E unless otherwise specified.

NOTE — Due consideration should be given to possible higher temperature of the winding and its possible effects on adjacent equipment while specifying insulating materials of Class B and higher.

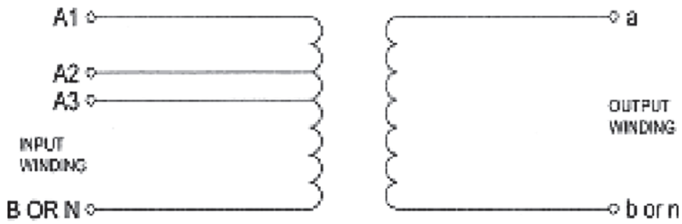

FIG. 1 TERMINAL MARKING FOR A CONTROL TRNSFORMER

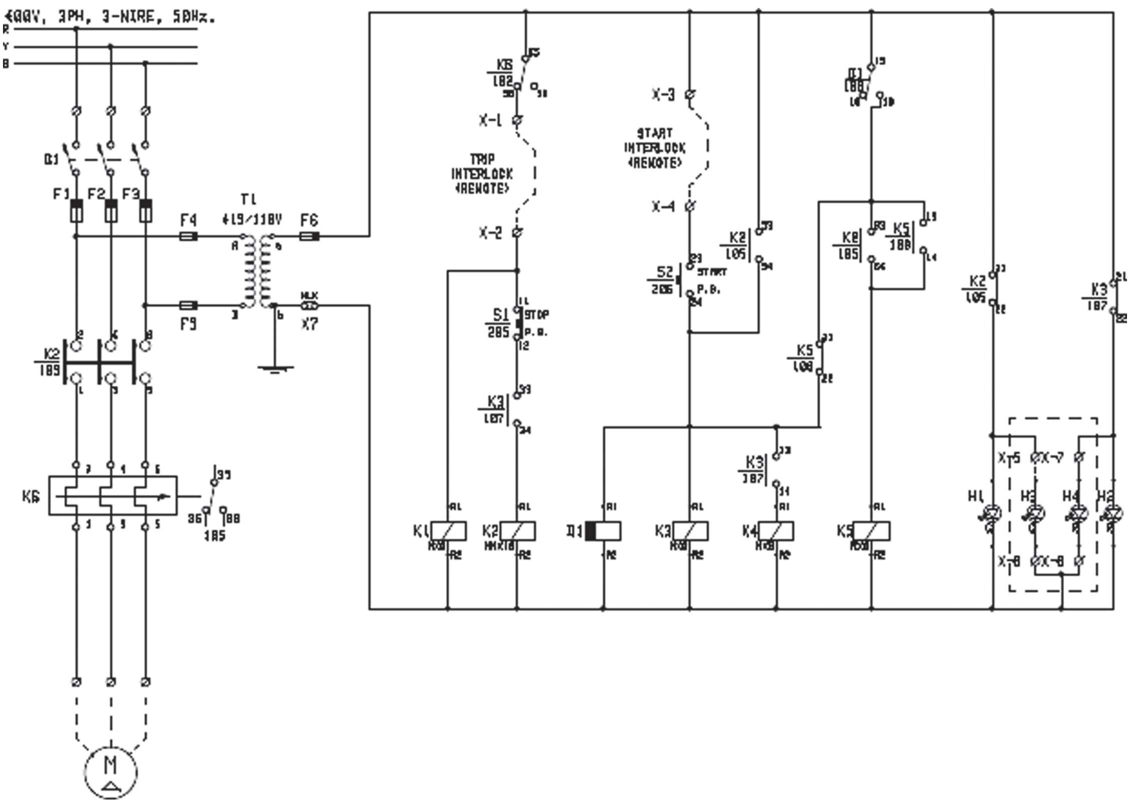

FIG. 2 TYPICAL DIRECT ON LINE (DOL) MOTOR STARTER SCHEME

8.2 Terminals

8.2.1 The terminals shall be of substantial mechanical construction and shall provide adequate electrical contact for appropriate cable used. Minimum size of conductor shall be 2.5 mm^2. Use of aluminium conductors shall be taken into account. Above 16A, a stud type terminal with shrouding is preferred.

8.2.2 The terminals connection shall ensure that the necessary contact pressure is maintained sufficiently and permanently, even under vibrations and shocks.

8.2.3 Terminals shall not turn or get displaced when connections are made or removed.

8.2.4 Location of terminals shall permit easy access for wiring without affecting other connections.

8.2.5 No contact pressure shall be transmitted through insulating material other than ceramic or any other material with similar characteristics, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage of the insulating material.

8.2.6 Insulating materials with high comparative tracking index are preferable for terminal supports. Use of insulating materials of Material Group IIIb is not recommended.

8.2.7 Conductors shall not be secured by pinching screws.

8.3 Earthing

8.3.1 The metal frame assembly of the control transformer shall be provided with an earthing terminal. The earthing terminal shall be easily accessible. It shall be separate from mounting screws.

8.3.2 The earthing terminal shall be of adequate size and protected against corrosion and shall be mechanically clean.

8.3.3 The earthing terminals shall be identified by means of the symbol '⏚' marked in a legible and indelible manner on or adjacent to the terminal.

8.4 Limits of Temperature-Rise

8.4.1 The Temperature-rise of the winding of control transformer shall be not exceed the values listed in Table 1. The test shall be carried out in accordance with **9.4**

Table 1 Limits of Temperature–Rise of Windings (Measured by Resistance Method)

(*Clause* 8.4.1)

Sl No.	Class of Insulation	Maximum Value of	
		Temperature	Temperature-rise (Over a Reference Ambient Temperature of 50°C)
		°C	K
(1)	(2)	(3)	(4)
i)	E	140	90
ii)	B	150	100
iii)	F	175	125
iv)	H	200	150
v)	C	225	175

NOTE — *See also* Note under **8.1.**

8.4.2 The maximum temperature of the other metallic parts (for example core, frame, etc) in contact with insulating materials shall be limited solely by necessity of not causing any damage to the insulating materials.

8.5 Ability to Withstand Short Circuit

The control transformer shall be capable of withstanding without damage dynamic stresses and thermal effects of short circuit at terminals of output winding. The test shall be carried out in accordance with **9.10**.

9 TESTS

9.1 Classification of Tests

9.1.1 *Type Tests*

The following shall constitute type tests:

a) Verification of terminal markings (*see* **9.2**),
b) Measurement of winding resistance (*see* **9.3**),
c) Temperature rise test (*see* **9.4**),
d) Verification of dielectric properties (*see* **9.5**),
e) Measurement of insulation resistance (*see* **9.6**),
f) Measurement of no-load current (*see* **9.7**),
g) Output voltage tests (*see* **9.8**),
h) Measurement of impedance voltage (*see* **9.9**), and
j) Short circuit test (*see* **9.10**).

NOTE — The tests may be carried out in any order (*see* **9.6** and **9.10**) and on any one or different samples.

9.1.2 *Routine Tests*

The following shall constitute the routine tests:

a) Verification of terminal markings (*see* **9.2**),
b) Measurement of winding resistance (*see* **9.3**),
c) Dielectric test (*see* **9.11**),
d) Measurement of insulation resistance (*see* **9.6**),
e) Measurement of no-load current (*see* **9.7**),
f) Measurement of no-load output voltage (*see* **9.8.1**), and
g) Measurement of impedance voltage (*see* **9.9**).

9.1.3 *Special Test*

Co-ordination with protective device in input winding circuit (*see* **9.12**) test shall be carried out by mutual agreement between the purchaser and the manufacturer.

9.2 Verification of Terminal Markings

Terminal markings shall be verified in conformity with **6.2**.

9.3 Measurement of Winding Resistances

9.3.1 The resistance of both windings shall be measured at room temperature across their respective terminals with direct current. Care shall be taken that during the measurement, temperature of windings should not be affected.

For routine tests the values measured shall not exceed the values obtained for the transformer subjected to the temperature-rise test, taking into account the correction factor for difference in ambient temperature, if any.

9.4 Temperature-Rise Test

The terminals of input winding shall be applied the 110 percent of the rated output voltage at the rated frequency and the rated burden shall be connected across the terminals of output winding. Final steady state temperature shall be measured and recorded subjected to the following:

a) Ambient conditions shall not be more severe than specified in **7**.
b) The transformer shall be considered to have attained a steady state temperature when the rate of temperature-rise does not exceed 1 K/h.
c) The temperature-rise of the winding shall be measured by the increase in resistance method. The temperature-rise of the core, frame and other parts where accessible may be measured by thermometers or thermocouples.
d) Methods of temperature measurement are given in IS 9678.
e) Temperature-rise shall not exceed the limits prescribed in **8.4**.

9.5 Verification of Dielectric Properties

The test voltage of a value indicated in Table 2 shall be applied for 1 m between (a) all live parts and metal frame, core and earth terminal connected together, and (b) two windings.

The test voltage at the moment of application shall not exceed 50 percent of its value. It shall then be increased steadily within a few seconds to its full value and maintained for 1 min. The a.c. power source shall have sufficient power to maintain the test voltage irrespective of leakage currents. The test voltage shall have a practically sinusoidal wave form and frequency between 45 Hz and 65 Hz.

There shall be no puncture or flashover.

Table 2 Dielectric Test Voltage
(*Clauses* 9.5 *and* 9.11)

Sl No.	Rated Insulation Voltage U_i V	Dielectric Test Voltage (a.c.) (rms) V
(1)	(2)	(3)
i)	$U_i \leq 60$	1 000
ii)	$60 < U_i \leq 300$	2 000
iii)	$300 < U_i \leq 660$	2 500
iv)	$660 < U_i \leq 800$	3 000
v)	$800 < U_i \leq 1\,000$	3 500

9.6 Measurement of Insulation Resistance

The insulation resistance of each winding to other winding, core, frame and earth shall be measured at 500 V d.c. It shall not be less than 50 megaohms. This test shall be carried out after verification of dielectric properties (*see* **8.5**) or dielectric test (*see* **8.11**) as the case may be.

9.7 Measurement of No-Load Current

The no-load current in the input winding shall be measured and recorded at the rated frequency and at,

a) the rated voltage ; and
b) 120 percent of the rated voltage.

The output terminals of the winding shall be left open.

The variation in the value of the current measured at 120 percent of the rated voltage shall not exceed by more than 20 percent of the declared value at that voltage.

9.8 Output Voltage Test

9.8.1 *No Load Output Voltage Test*

The terminals of input winding shall be applied the rated input voltage at the rated frequency. The terminals of output winding shall be left open circuited. The value of the output voltage reading shall be compared with the rated output voltage. The voltage reading shall be within the value prescribed in **5.1.4**.

9.8.2 *Rated Output Voltage Test*

The terminal of input winding shall be applied the rated input voltage at the rated frequency. The output terminals shall be connected to the rated burden. The voltage at the output terminals shall be measured and recorded. The voltage reading shall be compared with the rated output voltage. The variation in the reading shall be within ± 5 percent of the declared value.

9.8.3 *Short Time Output Voltage Test*

The terminals of input winding shall be applied the rated input voltage at the rated frequency. Output terminals shall be connected to the rated short time burden at a specified power factor agreed to between the purchaser and the manufacturer. The voltage readings at the output terminals shall be measured and recorded. The value of the voltage reading shall be compared with the rated output voltage.

The voltage reading shall be within the value prescribed in **5.1.3**.

9.9 Measurement of Impedance Voltage

Impedance voltage shall be measured at rated frequency by applying voltage to one winding with other winding short circuited. The measurement may be made at any current corresponding to a value between 25 percent and 100 percent of the rated output.

The measured value of this voltage shall be corrected by increasing it in the ratio of rated current test current and shall be expressed as a percentage of rated voltage of corresponding winding.

For the purpose of routine test the corrected value shall not exceed the value obtained for the transformer subjected to the type tests.

9.10 Short Circuit Test

Prior to the short circuit test the transformer shall be subjected to the routine test specified in **9.1.2**.

At the beginning of the short circuit test the average temperature of the winding shall be below 50°C.

The input of the control transformer shall be the applied the rated input voltage at the rated frequency. The prospective short circuit current at point of connection to the supply terminals of the transformer shall be at least ten times the full load current at the rated output.

A protective device indicated by the purchaser shall be incorporated in the input winding circuit. The output

terminal shall be shorted with negligible impedance. The duration of the test shall be maximum 1 s.

The transformer shall be deemed to have withstand the short circuit test, if the following conditions are satisfied:

a) No physical deformation shall have occurred; and
b) The transformer shall pass routine tests as specified in **9.1.2** after the test.

9.11 Dielectric Test

The test voltage of the value indicated in Table 2 shall be applied for 1 s between: (a) all live parts and metal frame, core and earth terminals connected together, and (b) two windings.

The a.c. power source shall have sufficient power to maintain the test voltage irrespective of leakage currents. The test voltage shall have practically sinusoidal waveform and frequency between 45 and 65Hz.

If the transformer has previously been subjected to dielectric test, the test voltage shall be reduced to 85 percent of the specified test voltage. There shall be no puncture or flashover.

9.12 Co-ordination with Protective Device in the Input Winding Circuit

9.12.1 Input winding shall be applied 112.5 percent of the rated input voltage at the rated frequency and the output winding shall be left open. The prospective short circuit current at the point of connection to the supply terminals of the transformer shall be at least ten times the full load current at rated burden.

The input winding circuit shall incorporate protective device specified by the purchaser and a main switch of adequate rating. The switch shall be operated to turn supply 'ON' and 'OFF' for a minimum ten times. Interval between each cycle shall not be more than 30 s.

The protecting device shall not operate due to inrush current resulting from the switching operations.

9.12.2 The test shall be carried out in accordance with **9.10**. The protecting device shall operate and isolate the transformer from the supply within 1s.

10. INFORMATION REQUIRED WITH ENQUIRY AND ORDER

The technical information that the purchaser is required to supply with enquiry and order is given in Annex C.

ANNEX A

(*Foreword*)

GUIDELINES FOR CALCULATION OF VA BURDENS OF CONTROL CIRCUITS

A-1 Burden posed by the various devices connected to the output terminal a control transformer depends on the state of operation of the equipment connected namely:

a) Pick up/hold on/d.c. energized condition for relays/contactors; and
b) 'ON/OFF' condition for indicating lamp and hooters/buzzers.

A-2 Based on the logic of operation the devices, the following burdens shall be computed:

a) Maximum hold-on (continues) VA burden of all the devices expected to operate simultaneously,
b) Maximum short time (pick-up) VA burden of all the devices expected to operate simultaneously, and
c) Maximum lead burden of connecting cables for above conditions [*see* **A-2** (a) and (b)]

A-3 Summation of burdens shall be done by vectorial addition, since an algebraic addition of the burdens shall generally result in higher value than that is functionally required.

A-4 A schematic diagram for the starter is shown in Fig. 2 and control circuit equipment details are listed in Table 3.

A typical calculation of VA requirement of a control circuit for a motor starter is a given in **A-4.1** to **A-4.4**.

Table 3 Equipment Details

(*Clause* A-4)

Sl No.	Equipment Description	Burden Data For Each Equipment					
		Hold On			Pick Up		
		W	VA	cos θ	W	VA	cos θ
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Main switch	These equipment make no contribution to burden					
ii)	Main fuses						
iii)	Fuses for control transformer						
iv)	Link for control transformer						
v)	Thermal overload relay						
vi)	Stop push button						
vii)	Start push button						
viii)	Main contactor	45	135	—	—	1 650	0.4
ix)	Auxiliary contactors	—	8	0.38	—	65	0.69
x)	OFF delay timer	10	20	—	55	85	—
xi)	Indicating lamps	7	—	—	—	—	—
xii)	Control transformer	—	—	—	—	—	—

Particulars:

a) System : 400 V 3 phase, 3 wire

b) Control circuit voltage : 110 V

c) Cable data:

1) cross-section : 1.5 mm²

2) length of wire : 50 m (if burden on significant)

d) Resistivity of wire (at 50°C) : 12 Ω/km

A-4.1 Individual equipment burden is generally given in terms of VA at power factor or VA and W. They are available from equipment manufacturer. Remaining parameters shall be found out by using following formulae:

$$W = VA \cos\theta$$

$$VAR = VA \sin\theta$$

$$\cos\theta = \frac{W}{VA}$$

$$\sin\theta = \sqrt{1-\cos^2\theta}$$

parameters or the equipments are listed in Table 4

A-4.2 Selection of the Operations

a) Maximum hold-on (continuous) VA, and

b) Maximum short time (pick up) VA.

The following listed (1 to 5) are normal maximum possible operations of the control circuit. Individual equipment operation (such as, pick-up/hold on/on) is noted against each control circuit operation :

1) Energization of feeder by main switch :

i) Auxiliary contractor (k1) Pick-up

ii) Indicating lamps (H1, H3) ON

Table 4 List of Control Circuit Equipment Burden Parameters

(*Clause* A-4.1)

Sl No.	Equipment Description	All burden parameters or the equipments are listed in Table 4 Coil Data							
		Hold-On				Pick-Up			
		VA	W	VAR	cos θ lagging	VA	W	VAR	cos θ lagging
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Main contactor	135	45	127	0.33	1 650	660	1 512	0.4
ii)	Auxiliary contactor	8	3	7.4	0.38	65	45	47	0.69
iii)	Timer	20	10	17	0.5	85	55	65	0.65
iv)	Indicating lamp	—	7	—	—	—	—	—	—

2) 'START' push button manual simulation

i)	Status after simulation	(Transient condition)
ii)	Auxiliary contactor (K1)	Hold-on
iii)	Auxiliary contractor (K3, K4, K5)	Pick-up
iv)	Main contractor (K2)	Pick-up
v)	Timer (D1)	Pick-up
vi)	Indicating lamps (H2, H4)	ON

3) After Simulating 'START' push button – steady state condition:

i)	Auxiliary contactor (K1, K3, K4, K5)	Hold-on
ii)	Main contractor (K2)	Hold-on
iii)	Timer (D1)	Hold-on
iv)	Indicating lamps (H2, H4)	ON

4) 'STOP' push button manual simulation/trip by thermal overload relay (KG) trip interlock:

i)	Auxiliary contactors (K1, K5)	Hold-on
ii)	Indicating lamps (H, H3)	ON

5) Auto start after resumption of control supply:

i)	Auxiliary contactors (K1, K3, K4, K5)	Pick-up
ii)	Main contactor (K2)	Pick-up
iii)	Timer (D1)	Pick-up
iv)	Indicating lamps (H2, H4)	ON

From the above list it is clear that at (3) the maximum hold VA occurs and at (5) the maximum short time VA occurs.

A-4.3 Calculation of the Burden

A-4.3.1 *Maximum Hold on VA Burden Calculations*

W : 4(3) + 45 + 10 + 14 = 81 W

VAR : 4(7.4) + 127 + 17 = 173.6 VAR

Total equipment VA burden

$$= \sqrt{(\mathrm{W})^2 + (\mathrm{VAR})^2}$$

$$= \sqrt{(81)^2 + (173.6)^2}$$

= 192 VA

Control circuit current, I

$$= \frac{\mathrm{VA}}{\mathrm{V}}$$

$$= \frac{192}{110} = 1.75\mathrm{A}$$

Lead resistance

$$= 12 \times \frac{100}{1\,000}$$

= 1.2

Lead burden (assumed purely resistive)

$= (I)^2 \times \mathrm{R}$ W

$= (1.75)^2 \times 1.2$ W

= 3.7 W

Total maximum hold-on VA burden

$$= \sqrt{(81+3.7)^2 + 173.6^2}$$

= 193 VA

Power factor (cos θ)

$$= \frac{W}{VA} = \frac{84.7}{193} = 0.44$$

A-4.3.2 *Maximum Short Time VA Burden Calculation*

Calculation of the burden

W : 4(45) + 660 + 55 + 14 = 909 W

VAR : 4(47) + 1512 + 65 = 1 765 VAR

Total equipment VA burden

$$= \sqrt{(\mathrm{W})^2 + (\mathrm{VAR})^2}$$

$$= \sqrt{(909)^2 + (1765)^2}$$

= 1985 VA

Control circuit current, I

$$= \frac{\mathrm{VA}}{\mathrm{V}}$$

$$= \frac{1985}{110}$$

= 18 A

Lead burden (assumed purely resistive)

$= (\mathrm{I})^2 \times \mathrm{R}$ W

$= (18)^2 \times 1.2$ W

= 389 W

Total maximum hold-on VA burden

$$= \sqrt{(909+389)^2 + 1\,765^2}\ \mathrm{VA}$$

= 2 191 VA

Power factor (cos θ)

$$\frac{\mathrm{W}}{\mathrm{VA}} = \frac{1\,298}{2\,191} = 0.59$$

A-4.4 The VA burden thus calculated may be suitably increased to take into account any possible circuit modifications, Future additions. Safety margins and any other consideration. It may then be rounded off to the nearest preferred rating as prescribed in **5.3.1** and **5.3.2.**

Rating of the transformer will therefore be:

a) Rated output : 250VA
b) Rated short time output : 2 500VA
c) Power factor at rated burden : 0.44 lagging
d) Power factor at short circuit rated burden : 0.59 lagging

ANNEX B

(*Clause* 6.1)

TYPICAL NAME PLATE

Control Transformer		TYPE XX
Manufacturer’s Name/Trade-Mark XXXXXXXXXXXX XXX		
Country of Origin XXXXXXXXXXXXX		IS XXXX
VA Ratings	XXX/XXXX	
Rated Voltage Input / Output	XXX/XX	50Hz
Insulation Class E		
Example of typical name plate		

ANNEX C

(*Clause* 10.1)

INFORMATION REQUIRED WITH ENQUIRY AND ORDER

C-1 The following technical information may be supplied with enquiry and order:

a) Rated input and output voltage.
b) Rated frequency.
c) Rated output and short time output: For example XXX/XXX.
d) Power factor of short time burden.
e) Class of insulation if other than class E.
f) Service condition if other than standard service condition (*see* **7**).
g) Special features such as limiting overall dimensions, mounting position/mounting arrangement.
h) Termination details such as conductor size and termination with lugs or without lugs.
j) Details of protective device for input winding.

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This Indian Standard has been developed from Doc No.: ETD 07 (6334).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi